

WHAT IS CLAIMED IS:

1. A bidirectionally vertical motion actuator, comprising:

a substrate;

a floating structure located above the substrate and comprising a suspended
5 membrane and at least one supporting beam extending outwardly from a boundary
of the suspended membrane in a direction substantially parallel to the suspended
membrane; and

at least one fixed electrode structure, which is insulated from the floating
structure, formed on a lateral side of the floating structure, and fixed onto the
10 substrate.

2. The bidirectionally vertical motion actuator according to claim 1, wherein
the floating structure and the at least one fixed electrode structure have the same
material and structure.

3. The bidirectionally vertical motion actuator according to claim 1, wherein
15 each of the floating structure and the at least one fixed electrode structure
comprises a first conductive layer, a dielectric layer on a top surface of the first
conductive layer, and a second conductive layer on a top surface of the dielectric
layer, and the first conductive layer of the at least one fixed electrode structure is
located on a top surface of the substrate.

20 4. The bidirectionally vertical motion actuator according to claim 1, wherein
the floating structure has four corners, each of which is supported and suspended
above the substrate by a pair of supporting beams perpendicular to each other.

5. The bidirectionally vertical motion actuator according to claim 1, wherein the at least one fixed electrode structure is arranged around the floating structure.

6. The bidirectionally vertical motion actuator according to claim 1, wherein the floating structure is formed with at least one slit on its surface.

5 7. The bidirectionally vertical motion actuator according to claim 1, wherein the floating structure is coated with a high reflective film on its top surface.

8. The bidirectionally vertical motion actuator according to claim 7, wherein the high reflective film is selected from one of a group consisting of a metal film and a dielectric film.

10 9. A vertical comb drive actuator that may move bidirectionally, comprising:

a substrate;

a floating structure located above the substrate and comprising a suspended membrane and at least one supporting beam extending outwardly from a boundary
15 of the suspended membrane in a direction substantially parallel to the suspended membrane, and at least one suspended interdigital electrode extending outwardly from a lateral side of the floating structure being formed; and

at least one fixed electrode structure, which is insulated from the floating structure, formed on a lateral side of the floating structure, and fixed onto the
20 substrate, the at least one fixed electrode structure being formed with at least one fixed interdigital electrode staggered with the at least one suspended interdigital electrode at a lateral side facing the floating structure.

10. The vertical comb drive actuator according to claim 9, wherein the floating structure and the at least one fixed electrode structure have the same material and structure.

11. The vertical comb drive actuator according to claim 9, wherein each of
5 the floating structure and at least one fixed electrode structure comprises a first
conductive layer, a dielectric layer on a top surface of the first conductive layer,
and a second conductive layer on a top surface of the dielectric layer.

12. The vertical comb drive actuator according to claim 9, wherein the
floating structure has four corners, each of which is supported and suspended
10 above the substrate by a pair of supporting beams perpendicular to each other.

13. The vertical comb drive actuator according to claim 9, wherein the at
least one fixed electrode structure is arranged around the floating structure.

14. The vertical comb drive actuator according to claim 9, wherein the at
least one suspended interdigital electrode and the at least one fixed interdigital
15 electrode are vertically overlapped and staggered to form a vertical comb drive
electrode structure.

15. The vertical comb drive actuator according to claim 9, wherein the
floating structure is formed with at least one slit on its surface.

16. The vertical comb drive actuator according to claim 9, wherein the
20 floating structure is coated with a high reflective film on its top surface.

17. The vertical comb drive actuator according to claim 16, wherein the
high reflective film is selected from one of a group consisting of a metal film and

a dielectric film.

18. A method for manufacturing a bidirectionally vertical motion actuator, comprising the steps of:

(a) providing a silicon-on-insulator (SOI) wafer, which comprises a first
5 silicon wafer, an insulation layer on a top surface of the first silicon wafer, and a second silicon wafer;

(b) forming a dielectric layer on the SOI wafer by way of deposition;

(c) depositing a conductive layer on the dielectric layer;

(d) etching the conductive layer, the dielectric layer and the second silicon
10 wafer simultaneously to form a proper trench; and

(e) forming an anisotropic etching groove on a backside of the SOI wafer.

19. The method according to claim 18, wherein the first silicon wafer is a handle silicon wafer.

20. The method according to claim 18, wherein the second silicon wafer is a
15 good conductor with low resistivity.

21. The method according to claim 18, wherein the insulation layer is a silicon oxide layer.

22. The method according to claim 18, wherein the step (d) is performed by way of deep silicon etching.

20 23. The method according to claim 18, wherein the top trench formed in the step (d) is selected from one of a group consisting of a ring-shaped trench, a

rectangular ring-shaped trench, and a line-shaped trench.

24. The method according to claim 18, wherein the top trench formed in the step (d) vertically penetrates through the conductive layer, the dielectric layer and the second silicon wafer.

5 25. The method according to claim 18, wherein the anisotropic backside etching groove penetrates through the first silicon wafer and the insulation layer.

26. The method according to claim 18, wherein the anisotropic etching groove communicates with the top trench.

27. An optical phase modulator, comprising:

10 a fixed mirror having a top surface coated with an anti-reflective optical film, and a bottom surface coated with a high reflective optical film;

 a bidirectionally vertical motion actuator located below the fixed mirror with a gap therebetween, the bidirectionally vertical motion actuator comprising a substrate, a floating structure fixed above the substrate, and at least one fixed
15 electrode structure fixed onto the substrate and located on a lateral side of the floating structure;

 a high reflective optical film arranged on a top surface of the floating structure; and

 an anti-reflective optical film arranged on a bottom surface of the floating
20 structure.

28. The optical phase modulator according to claim 27, wherein the fixed

mirror and the bidirectionally vertical motion actuator are bonded together with a spacer therebetween.

29. A light intensity controller, comprising:

a lever;

5 two torsional beams, which are respectively mounted to two sides of the lever and opposite to each other, the torsional beams serving as fulcrums fixed to a substrate; and

a bidirectionally vertical motion actuator connected to a front end of the lever.

10 30. The light intensity controller according to claim 29, wherein a rear end of the lever is located between two adjacent optical fibers.

31. The light intensity controller according to claim 29, wherein when the actuator moves down, a rear end of the lever moves upwards to change light-shielding area between two optical fibers and to control light intensity
15 accordingly.

32. The light intensity controller according to claim 31, wherein a displacement of the rear end of the lever is determined by positions of the torsional beams on an axial direction of the lever.

33. The light intensity controller according to claim 29, wherein the
20 bidirectionally vertical motion actuator comprises:

the substrate;

a floating structure located above the substrate and including a suspended membrane and at least one supporting beam extending outwardly from a boundary of the floating structure in a direction substantially parallel to the suspended membrane; and

5 at least one fixed electrode structure mounted to a lateral side of the floating structure and insulated from the floating structure, the at least one fixed electrode structure being fixed to the substrate.

34. The light intensity controller according to claim 29, wherein the bidirectionally vertical motion actuator is a vertical comb drive actuator that may
10 move bidirectionally.

35. The light intensity controller according to claim 34, wherein the vertical comb drive actuator comprises:

the substrate;

a floating structure located above the substrate and comprising a suspended
15 membrane and at least one supporting beam extending outwardly from a boundary of the suspended membrane in a direction substantially parallel to the suspended membrane, and at least one suspended interdigital electrode extending outwardly from a lateral side of the floating structure being formed; and

at least one fixed electrode structure, which is insulated from the floating
20 structure, formed on a lateral side of the floating structure, and fixed onto the substrate, the at least one fixed electrode structure being formed with at least one fixed interdigital electrode staggered with the at least one suspended interdigital

electrode at a lateral side facing the floating structure.

36. A torsion mirror, comprising:

a substrate:

a fixed electrode structure fixed to the substrate and formed with a set of
5 fixed interdigital electrodes and two supports apart from the fixed interdigital
electrodes;

a suspended mirror membrane located above the substrate and surrounded
by the fixed electrode structure, the suspended mirror membrane being formed
with a set of suspended interdigital electrodes staggered with the fixed interdigital
10 electrodes; and

two supporting beams, which connects the supports of the fixed electrode
structure to the suspended mirror membrane, respectively, for supporting the
suspended mirror membrane above the substrate and enabling the suspended
mirror membrane to rotate about the two supporting beams.

15 37. The torsion mirror according to claim 36, wherein the suspended mirror
membrane is rectangular and the suspended interdigital electrodes are formed on a
lateral side of the suspended mirror membrane.

38. The torsion mirror according to claim 36, wherein the suspended mirror
membrane comprises:

20 a circular mirror; and

four extensions connected to the circular mirror, wherein each of the

supporting beams is located between two adjacent extensions and the suspended interdigital electrodes are formed on the extensions.